

REMARKS

Claims 1-7, 12, and 16-19 are pending in this application. By this Amendment, claims 1, 2, 16, and 18 are amended; and claim 11 and withdrawn claims 8-10 and 13-15 are canceled. Support for the amendments to the claims may be found, for example, in the original claims. No new matter is added.

In view of the foregoing amendments and following remarks, reconsideration and allowance are respectfully requested.

I. Rejection Under 35 U.S.C. §102/103

The Office Action rejects claims 1-7, 11, 12, and 16-19 under 35 U.S.C. §102(b) as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over JP 5-181403 as disclosed in the background art of U.S. Patent No. 5,872,609 to Hiji et al. (hereinafter "JP 5-181403"). Applicant respectfully traverses the rejection.

Without conceding the propriety of the rejection, independent claims 1, 2, 16, and 18 are amended to more clearly distinguish over the applied reference. Specifically, each of independent claims 1, 2, 16, and 18 is amended to recite "wherein in the first radiation step, an angle of incidence of light radiated onto the UV-curable liquid crystal is adjustable." JP 5-181403, as evidenced by the machine translation submitted herewith, fails to disclose, expressly or inherently, such features and likewise fails to teach or suggest, or establish any reason or rationale to provide, each and every limitation as combined in independent claims 1, 2, 16, and 18 and, thus, does not anticipate and would not have been rendered obvious claims 1, 2, 16, and 18.

Instead, JP 5-181403 merely discloses that the process for production has (1) a step of irradiating an uncured object, which is light curable, containing materials exhibiting liquid crystallinity that are capable of a polymerization reaction with light rays having unified phases from two directions and (2) a step of completing curing over the entire part.

Additionally, in JP 5-181403, the volumetric hologram optical film having a layered structure with alternate refractive indices is manufactured by either applying an external field in one of the steps or applying different external fields in both steps. See machine translation of JP 5-181403, paragraphs [0007] and [0035].

Although JP 5-181403 discloses that the wavelength of light for diffraction is determined according to the refractive index of the material of the film and the pitch of the layered structure, the reference fails to disclose how the pitch of the layered structure is determined. See machine translation of JP 5-181403, paragraph [0018].

Accordingly, JP 5-181403 fails to disclose, expressly or inherently, each and every feature of claims 1, 2, 16, and 18 and, thus, does not anticipate claims 1, 2, 16, and 18 at least because JP 5-181403 at least fails to disclose that "in the first radiation step, an angle of incidence of light radiated onto the UV-curable liquid crystal is adjustable," as recited in claims 1, 2, 16, and 18. Likewise, JP 5-181403 fails to teach or suggest, or establish any reason or rationale to provide, each and every limitation of claims 1, 2, 16, and 18, and thus would not have rendered obvious claims 1, 2, 16, and 18. Claims 3-7, 11, 12, 17 and 19 variously depend from claims 1, 2, 16, and 18 and, thus, also are not anticipated by and would not have been rendered obvious by JP 5-181403.

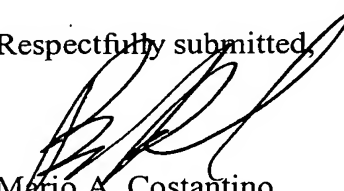
Accordingly, for at least the reasons set forth above, reconsideration and withdrawal of the rejection are respectfully requested.

II. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of the application are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,



Mario A. Costantino
Registration No. 33,565

Benjamin S. Prebyl
Registration No. 60,256

MAC:BSP

Attachments:

Petition for Extension of Time
Machine Translation of JP 5-181403

Date: July 2, 2009

OLIFF & BERRIDGE, PLC
P.O. Box 19928
Alexandria, Virginia 22320
Telephone: (703) 836-6400

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PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-181403

(43)Date of publication of application : 23.07.1993

(51)Int.Cl.

G03H 1/02
G02B 5/32
G02F 1/13
G02F 1/1333

(21)Application number : 04-154062

(71)Applicant : ASAHI GLASS CO LTD

(22)Date of filing : 24.04.1992

(72)Inventor : KORISHIMA TOMONORI
HIRANO MASAHIRO
HIRAI YOSHINORI
NIYAMA SATOSHI

(30)Priority

Priority number : 03125297

Priority date : 27.04.1991

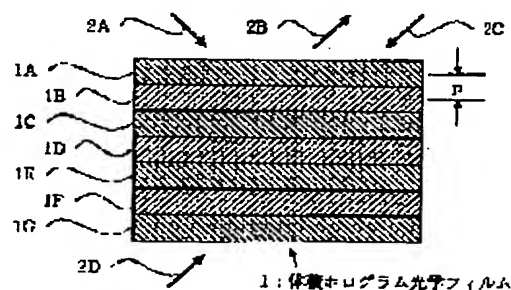
Priority country : JP

(54) VOLUMETRIC HOLOGRAM OPTICAL FILM AND PRODUCTION THEREOF AND LIQUID CRYSTAL OPTICAL ELEMENT FORMED BY USING THE SAME

(57)Abstract:

PURPOSE: To provide the process for production of the volumetric hologram optical film having good diffraction efficiency and productivity.

CONSTITUTION: The process for production has a 1st stage of irradiating photosetting uncured materials contg. compds. having polymn. reactivity and exhibiting liquid crystallinity with rays having unified phases from two directions (for example, 2A and 2D) and a 2nd stage of completing curing over the entire part. The volumetric hologram optical film 1 which is cured by changing the orientation states of the molecules of the compds. exhibiting the liquid crystallinity by the impression of external fields and generates a difference in refractive indices from the difference in the orientation states is produced by these two stages.



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CLAIMS

[Claim(s)]

[Claim 1]A volume hologram optical film having a layer system from which it is a volume hologram optical film which consists of high molecular compounds, molecular arrangement of a high molecular compound changes periodically by the inside, and a refractive index changes periodically by that cause.

[Claim 2]A manufacturing method of a volume hologram optical film which consists of high molecular compounds characterized by comprising the following.

A process which exposes uncured material of a photoresist containing material in which liquid crystallinity in which a polymerization reaction is possible at least is shown to a beam of light with which a phase gathered from a 2-way, and makes it harden uncured material of a photoresist in layers using interference of those two beams of light.

Subsequently, a layer system from which a refractive index changes periodically by the inside by impressing an outer field which consists of a process of completing the whole hardening, and impresses an outer field only at process of one of these, or is different at both processes.

[Claim 3]A manufacturing method of a volume hologram optical film pinching uncured material of a photoresist between conductors of a couple, and impressing and manufacturing an electric field as an outer field in claim 2.

[Claim 4]A manufacturing method of a volume hologram optical film containing a liquid crystal which does not produce hardening in any of 2 times of curing processes in claim 2 or 3.

[Claim 5]A manufacturing method of a volume hologram optical film containing a cross-linking monomer in any 1 of claims 2-4.

[Claim 6]A liquid crystal optical element pinching a volume hologram optical film manufactured with any 1 manufacturing method of claims 2-5 between substrates with an electrode.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]**[0001]**

[Industrial Application]This invention relates to the volume hologram optical film by a high molecular compound, its manufacturing method, and the liquid crystal optical element using it.

[0002]

[Description of the Prior Art]That by which the layer from which a refractive index differs in a resin film was laminated in layers as a volume hologram optical film is known. This exposes it to the beam of light with which the phase was equal to the photoresist compound from the 2-way which is not on a straight line, for example, produces interference, and the layer from which a refractive index differs in layers is laminated, and it is made and manufactured.

[0003]This volume hologram optical film penetrates selectively the specified wavelength which becomes settled with that pitch (interval of a portion with a high refractive index, and a portion with an adjoining high refractive index), or reflects it selectively. For this reason, use is considered by the HUD, a high mounted stop lamp, a solid three-dimensional display, etc.

[0004]

[Problem(s) to be Solved by the Invention]However, in the photoresist compound used for a volume hologram optical film, even if it is exposed to the beam of light with which the phase gathered from the 2-way which is not on a straight line and stiffened the photoresist compound in layers using interference of those two beams of light, there was also a problem that the difference of a refractive index did not arise slightly. For this reason, when it was used as a volume hologram, the diffraction efficiency of light was bad, and cannot but increase the number of layers, and to raise diffraction efficiency was desired.

[0005]It is made for the structure of the conventional volume hologram optical film to differ in the refractive index of a layer and a layer alternately [at least]. For this reason, material composition was changed for every layer, or at least one layer was made to include a minute opening. For this reason, if it is going to obtain a hologram uniform as a whole, adjoining two-layer refractive index difference cannot be enlarged. If it was going to enlarge refractive index difference of the adjoining layer, it had the problem that the whole homogeneity worsened.

[0006]

[Means for Solving the Problem]It is made in order that this invention may solve the above technical problems, It is a volume hologram optical film which consists of high molecular compounds, and molecular arrangement of a high molecular compound changes periodically by the inside, and, thereby, a refractive index provides a volume hologram optical film having a layer system which changes periodically.

[0007]It is a manufacturing method of a volume hologram optical film which consists of high molecular compounds, A process which exposes uncured material of a photoresist containing material in which liquid crystallinity in which a polymerization reaction is possible at least is shown to a beam of light with which a phase gathered from a 2-way, and makes it harden uncured material of a photoresist in layers using interference of those two beams of light, Subsequently, by impressing an outer field which consists of a process of completing the whole hardening, and impresses an outer field only at process of one of these, or is different at both processes, A manufacturing method of a volume hologram optical film in which a refractive index is characterized by manufacturing a volume hologram optical film which has a layer system which changes periodically by the inside is provided.

[0008]A manufacturing method of a volume hologram optical film pinching uncured material of the photoresist between conductors of a couple, and impressing and manufacturing an electric

field as an outer field, And a manufacturing method of a volume hologram optical film containing a liquid crystal which does not produce hardening in any of 2 times of those curing processes, and a manufacturing method of a volume hologram optical film, wherein they contain a cross-linking monomer are provided.

[0009]A liquid crystal optical element pinching a volume hologram optical film manufactured with those manufacturing methods between substrates with an electrode is provided.

[0010]With a volume hologram optical film which consists of a high molecular compound of this invention, there is a tendency which material in which liquid crystallinity stiffened by reaction in accordance with a specific direction inside the film is shown arranges in a portion which an outer field is impressed and was stiffened. In a portion stiffened without impressing an outer field, material in which liquid crystallinity is shown is not arranged in accordance with an almost specific direction. According to a difference of this array condition, a refractive index changes repeatedly and has a layer system which becomes almost constant [a refractive index] in respect of being vertical to that specific direction.

[0011]Unlike the conventional volume hologram optical film, in this invention, an oriented state is changed between two-layer [adjoining]. For this reason, adjoining two-layer refractive index difference can be enlarged. And since these layers are intrinsically the same as a material, homogeneity as the whole is good.

[0012]Drawing 1 is a sectional view of an example of a manufacturing-by this invention volume hologram optical film. it sets to drawing 1 — 1 expresses a volume hologram optical film and the layers 1A, 1C, and 1E with a high refractive index, 1G —, and the layers 1B and 1D with a low refractive index and 1F — are laminated. In order to make it intelligible, a layer with a high refractive index and a layer with a low refractive index are expressed with this figure in the state where it dissociated thoroughly, but a refractive index is usually changing gradually.

[0013]A layer with this high refractive index and a layer with a low refractive index combine, and it is 1 pitch (p). It has become. Specifically, between the layer 1A with a high refractive index and the layers 1C with a high refractive index which adjoins on both sides of the layer 1B with a low refractive index is 1 pitch (p). It becomes.

[0014]Two layers which material in which liquid crystallinity is shown was itself, or a difference specifically attached to the molecular arrangement when polymers-izing by a reaction with other materials are made. Specifically, it has specific arrangement in a unit which has a main chain or a side chain of resin in a layer of a method of one at least. Thereby, refractive indices differ between layer of one of these, and a layer of another side. If it specifically sees in micro, even if orderly arrangement is shown, if it sees on a macro target, there is an array state near an array state near the state where it has arranged almost at random, and the state where arrangement near a certain specific direction almost in parallel was carried out. It may be made for the specific directions of this arrangement to differ. According to a difference of this arrangement, a difference is attached to a refractive index.

[0015]According to this invention, by taking the above-mentioned composition, large refractive index difference can be taken and diffraction efficiency can be improved.

[0016]Although a volume hologram optical film of this invention uses a compound of a photoresist similarly to a volume hologram optical film with the conventional photoresist compound, material in which reactivity is in it and liquid crystallinity is shown is included. For this reason, the 1st process that exposes it to a beam of light with which a phase gathered from a 2-way, and stiffens uncured material of a photoresist in layers using interference of those two beams of light, Subsequently, it can distinguish between arrangement of the molecule at the time of polymers-izing by impressing an outer field which impresses an outer field only at one process with the 2nd process of completing the whole hardening, or is different at both processes.

[0017]In this invention, since refractive index difference produced from a difference of this molecular arrangement is used, refractive index difference between layers of a hologram can be enlarged.

[0018]In this invention, it diffracts by a layer from which a refractive index differs. In this case, it becomes settled in a refractive index of material of a film, and a pitch of a layer system of which wavelength light is set as the object of diffraction. For example, when a refractive index uses a resin material which is 1.5 grade, in order to reveal the diffraction effect before ultraviolet [with a wavelength of about 300 nm] and near-infrared rays with a wavelength of about 1500 nm, it is a pitch (p) of 50 nm – about 500 nm. What is necessary is just to consider it as a layer system. Using high order diffraction is also considered. For this reason, what is necessary is just to make into a layer system of a pitch of 50 nm – about 500 nm a pitch (distance with a layer with a high

refractive index which adjoins a layer with a high refractive index) of a layer system.

[0019]What is necessary is just to fix a pitch to diffract only light of specific wavelength.

Thereby, only specific wavelength is penetrated or it can reflect. Thereby, it can use as reflecting layers and transmission layers, such as a HUD, a high mounted stop lamp, and a solid three-dimensional display.

[0020]What is necessary is just to change a pitch according to the range to diffract light of a certain amount of wavelength band. Thereby, a specific wavelength band is penetrated or it can reflect. Thereby, it is applicable to heat reflective glass etc. which reflect only a near infrared ray.

[0021]In this invention, a difference is attached to arrangement of material in which liquid crystallinity is shown at reaction time polymers-ized. For example, if it polymerizes impressing an electric field when material in which liquid crystallinity which there is reactivity and has positive dielectric anisotropy is shown is used for uncured material of a photoresist, having included it, material in which this liquid crystallinity is shown will be arranged in parallel with an electric field. If an electric field is not impressed, unless orientation treatment special to a substrate which becomes an interface is carried out, if it usually sees on a macro target, it will arrange almost at random. For this reason, a molecule (a main chain or a side chain) of material in which liquid crystallinity is shown in a high molecular compound will differ in an array state by a situation of outer fields, such as an electric field, in reaction time polymers-ized.

[0022]However, the uncured material does not necessarily need to show liquid crystallinity before hardening, and arrangement should just become settled under influence of an outer field at the time of hardening. Although a compound in which liquid crystallinity is shown may be sufficient as all, a hardenability compound which is this uncured material mixes and uses a compound of non-liquid crystallinity in many cases, in order to satisfy other characteristics.

[0023]In this invention, a layer from which a refractive index by arrangement differing differs is laminated. Although, as for this refractive index difference, refractive-index n_1 changes to n_2 rapidly between two layers ideally, in a actual volume hologram optical film, a refractive index is usually changing gradually. For this reason, the minimum in a layer with low n_1 and refractive index is made into n_2 for the maximum in a layer with that high refractive index, and refractive index difference Δn is expressed with $\Delta n = n_1 - n_2$. In this invention, since this refractive index difference Δn relates to diffraction efficiency and half breadth of the diffracted light, it is so good that it is large, makes refractive index difference between this layer at least 0.02 or more, and carries out to 0.05 or more preferably.

[0024]Although the number of these layers is decided by desired diffraction efficiency, it is made into a pitch (a layer with a high refractive index and a low layer are made into 1 set, and it may be 1 pitch), and is ten to about 100 in general. Refractive index difference $\Delta n \geq 0.2$ When it is a grade, diffraction efficiency exceeds about 90% by laminating 30 pitches. Refractive index difference $\Delta n \geq 0.1$ In being a grade, in order to acquire comparable diffraction efficiency, it is necessary to laminate about 60 pitches.

[0025]In this invention, this layer system may be parallel to a film plane, and specification may be carrying out the angle inclination to a film plane. When close to a film plane in parallel, it becomes a reflection type volume hologram, and when vertically close to a film plane, it becomes a transmission type volume hologram.

[0026]For example, when entering light from the slanting upper part 2A to a volume hologram optical film of drawing 1, light of a specified wavelength decided by pitch and a refractive index is reflected in reverse slanting upper part 2B. For this reason, it is used for a HUD, a high mounted stop lamp, an infrared reflective window, etc.

[0027]In a volume hologram optical film (the layers 1A-1G are vertical to a film plane) from which the direction of a layer differs, when light of a specified wavelength falls out from 2A to 2B, a film plane will be penetrated. For this reason, colored presentation use which does not use a light filter is attained. If a hologram of catoptric light from a stereoscopic model of a laser beam and a reference beam is made to this volume hologram optical film, a solid three-dimensional display can be performed.

[0028]Uncured material of the photoresist of this invention includes material in which liquid crystallinity is shown in part at least at the time of hardening. What is necessary is just to polymers-ize material in which this liquid crystallinity is shown in response to the time of photo-curing with itself or other materials. As for uncured material of the photoresist of this invention,

what becomes a homogeneous solution is preferred. Although a monomer of a photoresist which forms resin, and oligomer are generally used, as long as it is the material in which photo-curing is possible, organic matters, such as silicon and titanium, can also be used and a heating process may be used together if needed. Since that from which a mixture becomes a homogeneous solution can tend to do a homogeneous thing, it is preferred.

[0029] If uncured material in which photo-curing of a point important about here is possible in this invention contains a compound in which existing reactant liquid crystallinity is shown, other materials are the points as which a compound in which the usual photo-curing is possible may be sufficient, and it is not needing a special material which is used for the usual volume hologram.

[0030] What is necessary is for itself to carry out photo-curing of the compound in which the liquid crystallinity of this invention is shown, or to react to uncured material of other photoresists and just to polymersize it. The liquid crystal phase can also use a nematic liquid crystal phase and a smectic liquid crystal phase, and it can be used if a refractive index which produces an array state which changes with impression of an outer field at the time of a polymerization, and is different by that cause is produced.

[0031] As for a cross-linking monomer, what has at least two double bonds, especially an acrylic group in intramolecular is preferred. Meltable polymer, a liquid crystal polymer, etc. may be used for a solution of a liquid crystal monomer in which thermal polymerization is possible, a non-polymerizable liquid crystal, a solvent, and uncured material. As for these, it is preferred that solubility is mutually. It is better to add it for such the purpose, when changing hologram nature by turning on and off of outer field impression since especially a non-polymerizable liquid crystal of low molecular weight enlarges speed of response to an outer field.

[0032] Thermal polymerization nature may be sufficient as a monomer which polymerizes as a liquid crystal monomer when not impressing an outer field, and there is a cyano-biphenyls system liquid crystal monomer which has an epoxy group at the end as the example. However, since what generally has photopolymerization nature can make it serve a double purpose at the time of impression of an outer field, and un-impressing, it is desirable. As the example, there is a liquid crystal monomer of what has an acrylic group ($\text{CH}_2=\text{CX}-\text{CO}-\text{O}-$ and X are H, F, and CH_3) in one end, and a cyano-biphenyls system and a benzoic acid phenyl ester system. In addition, additive agents, such as a viscosity controlling agent, colorant, and coloring matter, may be added to this.

[0033] Drawing 2 is a front view of a liquid crystal optical element which pinched a volume hologram optical film of this invention between substrates with an electrode. The volume hologram optical film 1 is pinched in drawing 2 by the substrate 4A which formed the electrode 3A, and the substrate 4B which formed the electrode 3B. A seal may be formed in an end of the volume hologram optical film 1 although not shown by this figure.

[0034] When this volume hologram optical film contains an unpolymerized liquid crystal or the hardened material itself has liquid crystallinity, by impressing an electric field between the up-and-down electrode 3A and 3B, orientation of a liquid crystal changes and a refractive index changes. Thereby, the characteristic of a hologram is changeable. It becomes possible to give the usual display and an indication of memory nature by this.

[0035] A manufacturing method of this invention is explained. In this invention, it is exposed to a beam of light with which a phase was equal to uncured material of a photoresist containing material in which liquid crystallinity is shown from a 2-way, and has the 1st process that stiffens uncured material of a photoresist in layers using interference of those two beams of light, and the 2nd process of subsequently completing the whole hardening. An outer field which makes a specific direction arrange material which this either shows the liquid crystallinity of an electric field, a magnetic field, etc. in process is impressed. Of course, an outer field different, respectively may be impressed to both processes. A volume hologram optical film in which a refractive index has by this a layer system which changes periodically by the inside can be manufactured.

[0036] In this case, if it irradiates with light to which a phase was equal from a 2-way of 2A and 2D of drawing 1, a layer system from which a refractive index by a difference of a **** array state of drawing 1 differs can be formed. What is necessary is just to irradiate with light from a 2-way of 2A and 2C, if you would like to shift 90 degrees of this layer system, and to carry out in the vertical direction. What is necessary is just to use a laser beam of a single mode as a parallel beam which spread using a beam expander as a feeding method of light with which this phase gathered, for example.

[0037] If it hardens without impressing an outer field, photo-curing will start and a hardened material will form. If material in which liquid crystallinity is shown is not influenced by an outer field, for seeing on a macro target and generally not producing specific arrangement, it reacts and is polymers-ized.

[0038] On the other hand, if it hardens impressing an outer field, a molecule of material in which liquid crystallinity which you were made to arrange compulsorily by outer field is shown will react and polymers-ize in the state. Usually, an outer field which is different at both two processes is applied, and while is good also as a different array state, although what is necessary is to impress an outer field only at the time of a process.

[0039] This produces a difference in the molecular arrangement state of material which shows liquid crystallinity between layers, and this serves as refractive index difference and functions as a hologram. That from which uncured material of a photoresist becomes a homogeneous solution in this invention is preferred. According to this method, a homogeneous volume hologram optical film is easy to be obtained.

[0040] Impression of an electric field of a curing process may be made reverse, light may be irradiated with and stiffened from a 2-way, without impressing an electric field first, and an electric field may be impressed and stiffened at the 2nd process. It is possible even if it uses a magnetic field which are other outer fields which make a compound in which liquid crystallinity is shown arrange, and deal in it instead of an electric field. But impression of an electric field is the simplest and productivity is good.

[0041] At two processes, an outer field can be given from two different directions, and an arrangement direction of a compound in which liquid crystallinity is shown in each layer can also be changed. Although use is limited extremely, film thickness is thin, and the following processes are also possible when making a hologram layer vertical to a film surface. At the time of film hardening, a surface treatment which makes a compound in which liquid crystallinity is shown arrange can be performed to a board contacted on the surface, and arrangement of a specific direction can also be formed in a specific direction under the influence at it.

[0042] moreover -- impressing an outer field selectively **** -- the 1st process -- partial **** -- hologram nature can also be given selectively, without making the whole into the same hologram by things. Strength and a direction of an exposure laser wavelength or an outer field can be changed selectively, and the hologram characteristic can also be changed selectively.

[0043] It can be considered as a value of a request of this refractive index difference by choosing suitably content etc. of material in which a difference of a refractive index produced according to a difference of arrangement of a molecule of a compound in which liquid crystallinity at the time of being polymers-ized is shown, irradiation time of two beams of light, leaving times, and liquid crystallinity are shown.

[0044] A volume hologram optical film of this invention can be used for the use same as mentioned above as the conventional volume hologram optical film. Specifically, there are a HUD, a high mounted stop lamp, an infrared reflective window, a solid three-dimensional display, etc. The usage may also use it, sticking on glass surfaces and plastic sides, such as a window, and it may be used, confining in lamination glass or a glass laminate. Hologram nature can also be made variable by using it for a liquid crystal optical element, carrying out.

[0045]

[Example]

The acrylic liquid crystal monomer which has a cyano-biphenyls group at the end as example 1 uncured material, the acrylic liquid crystal monomer which has a substituent of a benzoic acid phenyl ester system at the end, an acrylic non-liquid crystal monomer, and urethane system non-liquid crystal acrylic oligomer. The solution which mixed and obtained a photoreaction initiator and sensitizing dye was supplied on the plastic film, and the thickness of the solution was other plastic films about 10 micrometers in piles.

[0046] After considering it as the parallel ray with the beam expander, using an argon laser (wavelength of 514.5 nm) as a light source for exposure and making this into two light flux using a mirror, the solution layer was irradiated from the 2-way of 2A and 2D of drawing 1. The magnetic field was impressed and stiffened between the upper and lower sides in that case. Then, removed the magnetic field, and exposed the whole to ultraviolet rays, hardening was made to complete, and the volume hologram optical film was manufactured. This volume hologram optical film has green reflection.

When spectrometry was performed, the reflexogenic zone was seen near 540 nm.

[0047]The solution of example 2 Example 1 was cast on the plastic film substrate with an ITO electrode, the plastic film substrate with an ITO electrode of one more sheet was piled up on it, and the electric field of 50V was impressed and exposed to inter-electrode only at the time of a laser beam exposure. Then, the whole was exposed to ultraviolet rays, without impressing an electric field, and hardening was made to complete. This volume hologram optical film has green reflection like Example 1.

When spectrometry was performed, the reflexogenic zone was seen near 540 nm.

[0048]The volume hologram optical film was manufactured like Example 2 using the solution which added the further non-polymerizable liquid crystal composition "E-8" to the solution of example 3 Example 1. This volume hologram optical film has green reflection like Example 2. When spectrometry was performed, the reflexogenic zone was seen near 540 nm.

[0049]Between substrates with the electrode of this volume hologram optical film When the voltage of 100V was impressed, green reflection decreased.

[0050]When irradiating the whole with ultraviolet rays, the electric field was impressed without impressing an electric field using the same solution as example 4 Example 3 at the time of a laser beam exposure, and the volume hologram optical film was manufactured. This volume hologram optical film has green reflection like Example 3.

When spectrometry was performed, the reflexogenic zone was seen near 540 nm.

[0051]

[Effect of the Invention]The volume hologram optical film of this invention is easy to enlarge refractive index difference between layers, and a volume hologram optical film with high diffraction efficiency is easy to be obtained with a small number of layers. Especially an adjoining two-layer material may be intrinsically the same, and since molecular arrangement has a difference, the homogeneity as the whole is good and it is easy to manufacture it. There is also an advantage that the usual photoresist compound can be used, as uncured material of the photoresist to be used except the material in which liquid crystallinity is shown.

[0052]Make parallel the direction of the layer of a volume hologram optical film at a film plane, it is made vertical, or the volume hologram optical film of the various characteristics is easily obtained by [a certain] carrying out an angle inclination.

[0053]Various application is possible for this invention within limits which do not lose the effect of this invention.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]The sectional view for explaining the concept of the volume hologram optical film of this invention

[Drawing 2]The front view of a liquid crystal optical element using the volume hologram optical film of this invention

[Description of Notations]

1 : volume hologram optical film

1A, 1C, 1E, 1G: A layer with a high refractive index

1B, 1D, 1F : Layer with a low refractive index

2A, 2B, 2C, 2D: The direction of light

3A, 3B : Electrode

4A, 4B : Substrate

[Translation done.]